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INTEGRATED PEST IMPACT ASSESSMENT SYSTEM: AN INTERFACE TO A FOREST MANAGEMENT INFORMATION SYSTEM

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INTEGRATED PEST IMPACT ASSESSMENT SYSTEM: AN INTERFACE TO A FOREST MANAGEMENT INFORMATION SYSTEM

by

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ABSTRACT

Forest planners and managers, pest management specialists, and other resource specialists are in need of more efficient and effective means for evaluating implications of alternative management actions. Computerized systems to assist in impact evaluation can take one of two forms: (1) decisionmaking; or (2) information assimilation and presentation. The Integrated Pest Impact Assessment System (IPIAS) takes the second form and, because of its modular design and basis on vegetation linked characteristics, can be used for many forest management problems.

INTRODUCTION

A computer-assisted forest management information system is being developed, called the Integrated Pest Impact Assessment System (IPIAS). As the name implies, IPIAS consists of a linked set of models, data bases, and computer programs developed in the context of pest management concerns, specifically mountain pine beetle (MPB, *Dendroctonus ponderosae* Hopkins) impacts in Colorado. However, as IPIAS evolved, a framework emerged that offers considerable promise as a more general forest management and planning tool. This paper describes the development of IPIAS and illustrates some of the capabilities of the current version of the system.

DEVELOPMENT OF IPIAS

IPIAS was developed during a particularly dynamic period in the evolution of forest planning methods and related technology. There were substantial, rapid changes in forest planning and management procedures in the last decade in response to a number of legislative and public mandates and perceived needs

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within land management agencies. Interdisciplinary teams of resource specialists have undertaken comprehensive plans for the management of large heterogeneous tracts of forest land. Forests are routinely measured, mapped, and managed in terms of many interacting, and often conflicting, concerns. This has resulted in a large increase in data and data management efforts, forest-effect simulation capabilities, and multiple objective decisionmaking systems.

During this same time period, there were significant advances in computer hardware and software used in forest planning and management. In many respects, this was a mutually beneficial relationship, with new management needs stimulating advances in computer technology, and new computer technology opening additional areas of management capabilities. In a very short time period computer keyboards and CRT's have become standard equipment for forest managers.

Different components of on-line forest planning and management have had varying success in keeping up with the rapidly changing information processing capabilities and requirements. Most National Forests have computerized data bases (i.e., SYSTEM 2000 or "S2K"), especially for timber management. One or more stand (or tree) growth models are routinely used to systematically project the implications of alternative silvicultural activities. National Forests also use multiple-objective optimization programs (FORPLAN, Johnson et al. 1980) in their planning and decisionmaking. Forest pest management specialists are developing models of pest management systems (Campbell and McFadden 1977). However, few quantitative computerized models exist that include wildlife, recreation, or scenic quality components, and very few of these are capable of responding accurately to projected changes in specific forest characteristics.

Much of the impetus for the development of IPIAS was related to MPB impacts on ponderosa pine (Pinus ponderosa Laws) along the Front Range of the Colorado Rockies. Forest managers needed to develop treatment strategies that could effectively salvage damaged stands, control the MPB in currently infested stands, and protect susceptible stands. The benefits to be derived, in terms of traditional timber economic values, were not of major significance in the affected region (Averill et al. 1977). In fact, the principal factor motivating MPB control was the significant scenic value of the area and its major public use for recreation, tourism, and vacation home development. The capabilities to accurately project how these values might be affected by both insect- or treatment-induced changes in forest characteristics was nonexistent.

Forest Pest Management personnel of the U.S. Forest Service, Rocky Mountain Region, sponsored workshops in 1978 and 79 to define problems and identify research needs related to MPB control along the Front Range (Anonymous 1979a, 1979b). A 5-year plan was drafted during the workshops which called for the development of models that relate MPB and treatment effects to changes in economic, recreation, residential property, and publicly perceived scenic values. The various models were developed independently (Agricultural Enterprises, Inc. 1981, Daniel et al. 1981, Walsh et al. 1981, Walsh and Olienyk 1981), but with the goal of ultimately being integrated into a

comprehensive impact assessment system. An integrated system was developed as the first generation of IPIAS (Daniel et al. 1983), but, in many respects, full integration of the separate models was not fully realized.

Preliminary testing and extensive discussions with forest planners and managers indicated the need to carry IPIAS several steps beyond the first generation system. The next step was to link the IPIAS models to a forest stand model that would project growth and mortality as influenced by silvicultural treatments and effects of insect or disease pests. Perhaps the most significant step, however, was to add a geographic or spatial information component.

Tabular data (such as that used and produced by IPIAS) must be related to distinct spatial locations for effective forest planning and management. Typical forest offices contain a great deal of spatial data in the form of maps. Accessing this type of spatial data is often a significant task. Finding the desired map is usually only the first step in the data retrieval process. The maps may contain a color or numerical code (or both) that refer to tabular or textual data stored in another information system, such as computer files or more often, other hard copy material. In addition, significant changes may have occurred in the area since the maps were prepared; these changes may not have been noted on the map or in associated textual or tabular material.

This type of information display and analysis is inefficient, offers a great many opportunities for error, and is extremely cumbersome and time consuming to update or correct. Even so, considerable forest planning and management work is done using some version of this type of system and there has been observable progress toward streamlining and improving the related procedures.

The second generation of IPIAS was designed as an impact assessment and information system that would be adaptable to changing forest management and planning processes. Few of the system components are new. In many respects, IPIAS simply represents the integration and computerization of procedures that are now largely carried out manually by many forest planners and managers. The development of this type of interactive computerized information system is a logical step if forest planning and management activities are to meet the ever increasing requirements for data quantity and quality, documented evaluation and decision making processes, and effective monitoring of progress toward management objectives.

COMPONENTS OF IPIAS

IPIAS was designed to provide forest planners and managers, pest management personnel, and other resource specialists with a method to efficiently and effectively evaluate the implications of alternative management actions. Currently, the system focuses on predicting forest changes associated with MPB damage and related control activities. However, because of its modular design and versatility, IPIAS is potentially useful for a much wider range of forest pests. In fact, IPIAS is applicable to many management problems where changes in forest characteristics can be described or modeled.

IPIAS is composed of three major subsystems (Figure 1): (1) a geographic information system (GIS); (2) a data base management system (DBMS); and (3) a set of pest, forest and socioeconomic prediction models. The GIS contains spatial data, such as forest and stand boundaries, public land survey lines, and recreation sites. The DBMS holds all of the textual and tabular data pertinent to each timber stand in the GIS. The predictive models are used to determine the forest changes and socioeconomic impacts that could result from alternative management actions. These three subsystems, integrated into an interactive computer system (Figure 2), become a versatile and responsive management tool.

The principal components and features of each subsystem in IPIAS are described below. Specific components and models currently used in IPIAS are suited to the MPB in the Colorado Front Range. However, IPIAS's modular format allows other models and data bases to be readily substituted for applications to other forest and pest types. The basic form of the system, however, would remain the same.

DATA BASE MANAGEMENT SYSTEM - A DBMS facilitates the automated storage and retrieval of textual and tabular data. The DBMS used in IPIAS is a general purpose one, called SYSTEM 2000 or S2K. The U.S. Forest Service has used S2K for storing and analyzing timber sale accounts and timber management systems since 1975. S2K utilizes a user-oriented English-like language that enables a nonprogramer to easily build, access, and manipulate a data base. S2K can be accessed interactively or in a batch mode, and the user can define a new data base, or modify an existing one. S2K also has data reduction and analysis capabilities.

Every National Forest in the United States has a data base in S2K[1/]. The most numerous data relate to forest land resources, including recreation potential, soil types, wildlife data, and timber stand data, such as that used in the IPIAS models. S2K can store geographic identifiers, such as latitude-longitude coordinates, or narrative location descriptions. However, graphically displaying this spatial data requires a geographic (spatial) information system.

GEOGRAPHIC INFORMATION SYSTEM - A GIS, deals primarily with spatial or geographic data, rather than with textual or tabular data. In general, a GIS does not have to be an automated system; e.g., a map file or a world atlas could be considered a GIS. In recent years, however, the amount and complexity of resource data necessitates some degree of automation.

A computerized GIS consists of three basic subsystems: (1) data capture; (2) data analysis; and (3) data output. In the GIS, data is usually captured or copied into the computer utilizing a coordinate system that retains the geographic integrity of the resource data. The analytical component manipulates the original map data to produce any additional information specified by the user. The output component allows the user to reproduce the original data or derived data on a graphics terminal screen or as a "hard copy" map, chart, or graph.

1/ S2K is maintained by the USDA on a mainframe computer in Fort Collins, Colorado. Each forest accesses S2K via telecommunication.

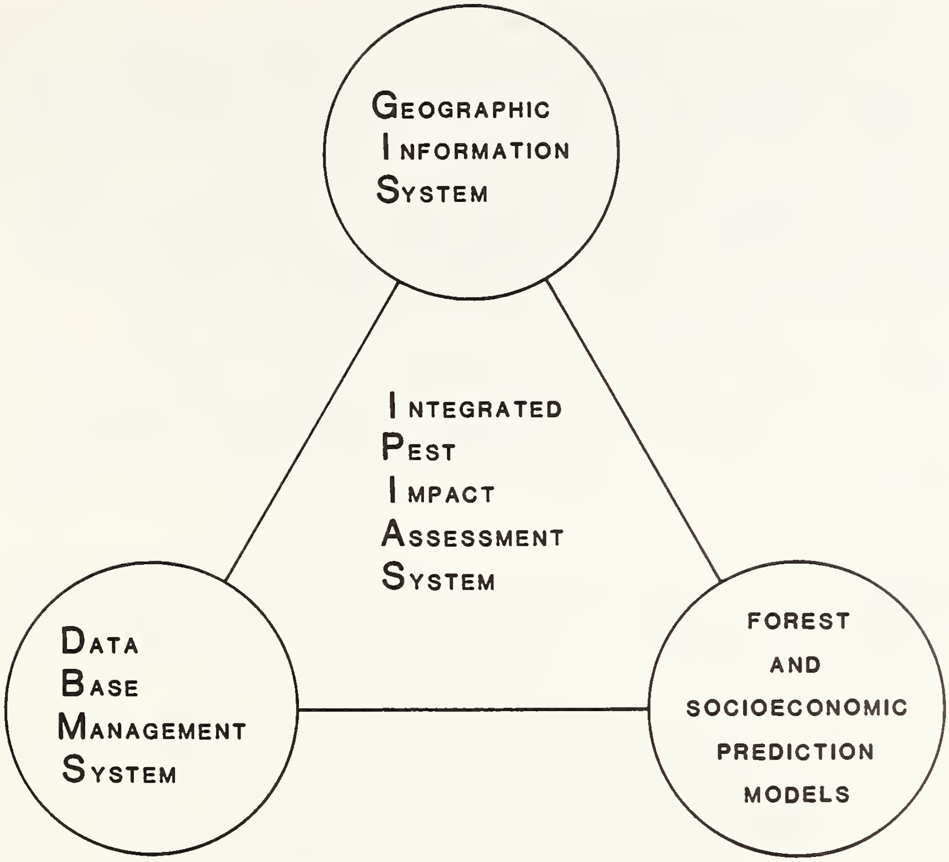

Figure 1 - General diagram of an Integrated Pest Impact Assessment System.

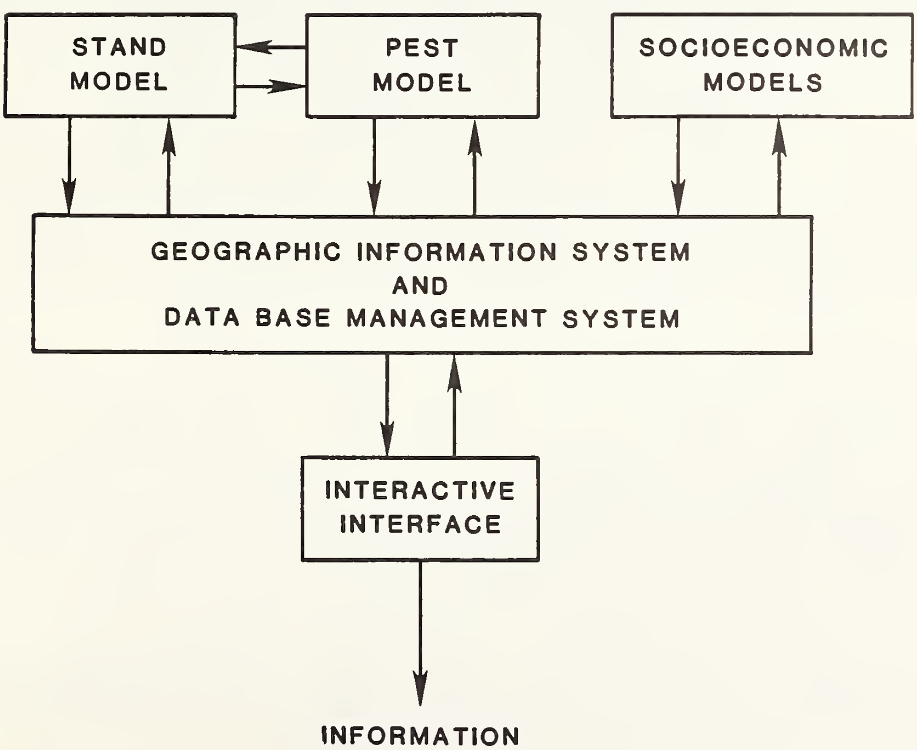

Figure 2 - Basic operating structure of IPIAS.

A typical computerized GIS data base contains a number of different types or "themes" of data, usually pertaining to the same geographic area. Map or cartographic data, such as public land survey lines, topographic features, or other map-related features with locational or spatial attributes are the types of data most commonly included in a natural resource data base. The data base may also contain other types of data such as locations of pest outbreaks, important big game ranges, recreation sites, or economically valuable timber stands. When several data themes are combined into one data base it is referred to as a "multiresource" data base; if all of the possible data themes are included, it is referred to as a "total resource" data base.

The computerized GIS performs many of the types of spatial manipulations traditionally performed manually, except that it is faster and more efficient (Goulet et al. 1981, Tomlin et al. 1981). In addition, the GIS can be used for the logical or arithmetic compositing of many maps at one time, a task that cannot easily be done manually.

The GIS component of IPIAS is the Map Overlay and Statistical System (MOSS), developed by the U.S. Fish and Wildlife Service's Western Energy and Land Use Team[2/]. MOSS currently operates in a minicomputer environment, which gives users on-site access and control.

There are currently over 100 analytical commands in MOSS, and map analysis can occur in either vector (polygon) or raster (cell) modes. A number of data sources can be used in MOSS, including digital terrain models and satellite imagery such as LANDSAT. For each point, line, or polygon on a map, there can be up to 30 characters of identifying information, e.g., soil type, town, and geologic strata. The 30 character limit was expanded in IPIAS to accommodate the multiple fields of data for each timber stand stored in the corresponding S2K data file. The ability to manipulate and display the spatial characteristics of S2K timber stand data, the multiple data themes possible in the GIS data base, and the capability for predictive model outputs were the final links needed to meet the objectives for IPIAS.

FOREST AND SOCIOECONOMIC PREDICTION MODELS - A number of separate prediction models are used in IPIAS to project the effects of management actions over time. A basic stand growth and mortality model is integrated with a pest effects model to predict changes in forest characteristics that would result from various silvicultural and pest-related activities. The resulting stand characteristics are used as input data for a set of models that predict an array of socioeconomic effects.

Because most forest management actions result in some change in the numbers, species, and sizes of trees, all of the components in IPIAS depend, in some way, on the output from the STAND model. The STAND model provides projections of future forest conditions based on initial inventories, growth and mortality parameters appropriate to the stand, and any prescribed management changes such as thinning or harvesting. The precision and level of detail of these projections determines the capabilities of the other models in IPIAS. Generally, stand tables should include at least numbers, sizes, and

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[2/] The MOSS software, which is in the public domain, is supported by the U.S. Fish and Wildlife Services Western Energy and Land Use Team and the U.S. Bureau of Land Management's Denver Service Center.

species of trees if estimates of pest susceptability, scenic quality, or economic products are needed. More precise predictions of the biological and socioeconomic effects of forest changes could be made if a more comprehensive forest ecosystem similator, including data on understory vegetation, down timber and slash, and quantity and quality of water runoff, were available.

The STAND model currently used in IPIAS is an adaptation of GROW (Anonymous 1983a). This model is used extensively for Front Range National Forests, especially previously unmanaged stands. GROW provides predictive stand tables, in 2-inch diameter classes, and volume computations for essentially 10-year time periods. The user can specify a variety of management actions, in terms of types of thins or cuts and when they occur. Residual stand conditions are used as input to pest and socioeconomic models at each specified time period. The STAND model was modified to maintain tree species identification and to allow interaction with the MPB model component at annual time periods.

The PEST model projects any growth reductions and mortality in stands of a host species due to the activities of a particular pest over time, based on timber stand information from the STAND model. The PEST model typically uses information on the effects of variations in the size and density of the host species on stand susceptability, pest population dynamics during and between outbreaks, and the susceptibility of adjacent stands in the future due to their proximity to currently infested stands. The interaction between the STAND and PEST models must be linked on a time cycle that is appropriate for the dynamics of the subject pest. For example, some diseases may require a 5- to 10-year cycle, while some insect pests, because of their more dynamic nature, may require a yearly cycle.

In the current MPB version of IPIAS, the PEST model is a generalized model that reflects expert opinion. The model is "triggered" by a combination of host and pest characteristics including stand density, current faders[3/], green infested trees (trees that will fade next year), and estimated attack ratios. The MPB model provides estimated numbers of dead pines in 2-inch size classes on an annual cycle as input to the STAND model.

The socioeconomic models consist of a set of equations that relate forest characteristics to the various economic, recreation, and aesthetic values being estimated. Some of these models are straightforward and based on tested relationships; e.g., the model that predicts the present worth in dollars of a standing volume of sawtimber. Given accurate estimates of the number and size of trees in the residual stand, from the STAND and PEST models, computations involving volumes, prices, and discounts to get present worth are direct and readily accepted. Other models, such as those that estimate various types of recreation potentials, or public perception of scenic beauty are less well established. Still, the principal is the same: statistical relationships between forest characteristics, such as the sizes, species, and densities of trees and the amount of insect damage and recreation use or perceived scenic beauty are used to develop models (Buhyoff et al. 1982, Schroeder and Daniel

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[3/] "Fader" is a colloquial term for a ponderosa pine tree having a discolored (yellow/orange) appearance which results from attack by the mountain pine beetle.

1981, and Walsh et al. 1981). Once developed, these models can be used to provide estimates of recreation potential and scenic beauty, based on projections of the characteristics of the residual stands.

IPIAS contains several sets of socioeconomic models developed specifically for the Colorado Front Range. Economic input-output models for three Front Range communities estimate the local effects of changes in income from forest industries, tourism, and "foot loose" residents (retirees and commuters) that result from changes in forest quality (tree density and insect damage). Other models estimate the effects of changes in forest quality on residential property values and potential for recreational use. Scenic quality models estimate the effects of forest change in terms of on-site (within the canopy of the affected forest) and vista perspectives. Depending on user needs any or all subsets of socioeconomic effects can be displayed.

USER INTERFACE - In typical IPIAS applications, the user follows a computer-presented "menu" of queries and responses. Components and functions needed to respond to a user query are automatically activated within the system. Although an expert knowledge of computer hardware or programing is not needed, considerable knowledge of the forest area, management goals and constraints, and the processes affecting the forest and its public use is necessary to effectively use the system.

Some computer and data base expertise is required to "load" the system. Basic input requirements are initial stand inventories and digitized stand boundaries. All of the models in the system rely on beginning inventories as a starting point; therefore, the initial data must be both complete and accurate. Input can include additional forest data (such as information on understory vegetation, indicators of pest populations, land use and ownership, topography, compartment and forest boundaries, recreation areas and use, and location of scenic vista points) and a variety of parameter values (such as prices for sawtimber, pulp, or other wood products; applicable discount rates; and recreational uses of different forest areas). These inputs are usually obtained from existing specialized data bases, are standard for the forest or region, or are provided by appropriate resource specialists. Data is entered in tabular or map form or generated within the system, as when areas of pest damage are overlayed on stand maps to produce a table of damage value by stand.

The types and amount of output from the system depend on user needs. For example, some output may be relevant only for certain areas and management options or for particluar members of the planning team. Determining the significance of system output usually requires the judgment of an appropriate specialist, such as a silviculturist, landscape architect, recreation planner, or economist. IPIAS, then, does not replace the interdisciplinary team, but does provide a framework for integrating the various inputs and outputs necessary for a comprehensive forest plan. Output from IPIAS can be in a variety of formats, including tabular, graphic, or maps of areas that meet certain specifications. Many of the available output options are illustrated in the following section.

SAMPLE APPLICATION OF IPIAS

An example (not completely hypothetical) of a typical management query is presented below to illustrate some of the capabiities of IPIAS. The context for the example is the MPB problem along the Front Range; however, the reader is encouraged to consider how other problems could be handled if the appropriate component models and data were entered into the IPIAS framework.

Context. MPB has been causing widespread mortality in ponderosa pine along the Front Range of Colorado for the past 10 years, in-including parts of the Pike and San Isabel National Forests. The Rampart Range Road, a major recreation and scenic corridor bisects a group of forest compartments severely affected by the MPB. The subject compartments are part of a digitized GIS spatial data base, and the S2K tabular data base contains generalized timber stand data (Stage I data based on aerial photos and minimal ground verification) for each stand. Areas that are sensative because of their scenic value were identified by a recreation specialist and a landscape architect. The area was determined to be suitable for MPB treatment efforts, and the types of stands in the area were identified as candidates for treatment during the current planning cycle.

QUERY - In this context the forest manager must decide on the specific actions and locations needed to control the MPB problem.

An appropriate IPIAS query might be:

Considering only U.S. Forest Service lands within a specified six-compartment area, select all of the ponderosa pine stands of sawtimber size with current MPB-caused mortality in excess of 0.1 tree/acre on sites with slopes <40% that are within 0.5 mile of the Rampart Range Road or are within the "seen area" from the Devil's Devil's Head vista point.

This query would initiate a number of automatic data file searches, computations, and selections within IPIAS. Stands meeting the specified criteria would be identified and made available for spatial display, such as the map in figure 3, or for tabular output as directed by the user. A more current and detailed inventory (Stage II) of the identified stands may be made prior to considering alternative management actions. The inventory may result in changes in both the spatial (stand boundaries) and textual (species and number of trees) data bases, as illustrated in figure 4.

Updating spatial information in IPIAS requires digitizing any changed stand boundaries. In this example, the timber compartments needing changes are selected out of a larger segment of the geographic data base (e.g., the Devil's Head quad), stand boundaries in the selected area are redigitized to reflect the new data, and the updated compartments are inserted into the "window" outlined by the original compartment boundaries. No changes are made in the unaffected areas of the data base. The associated tabular data are changed as needed through conventional file editing procedures.

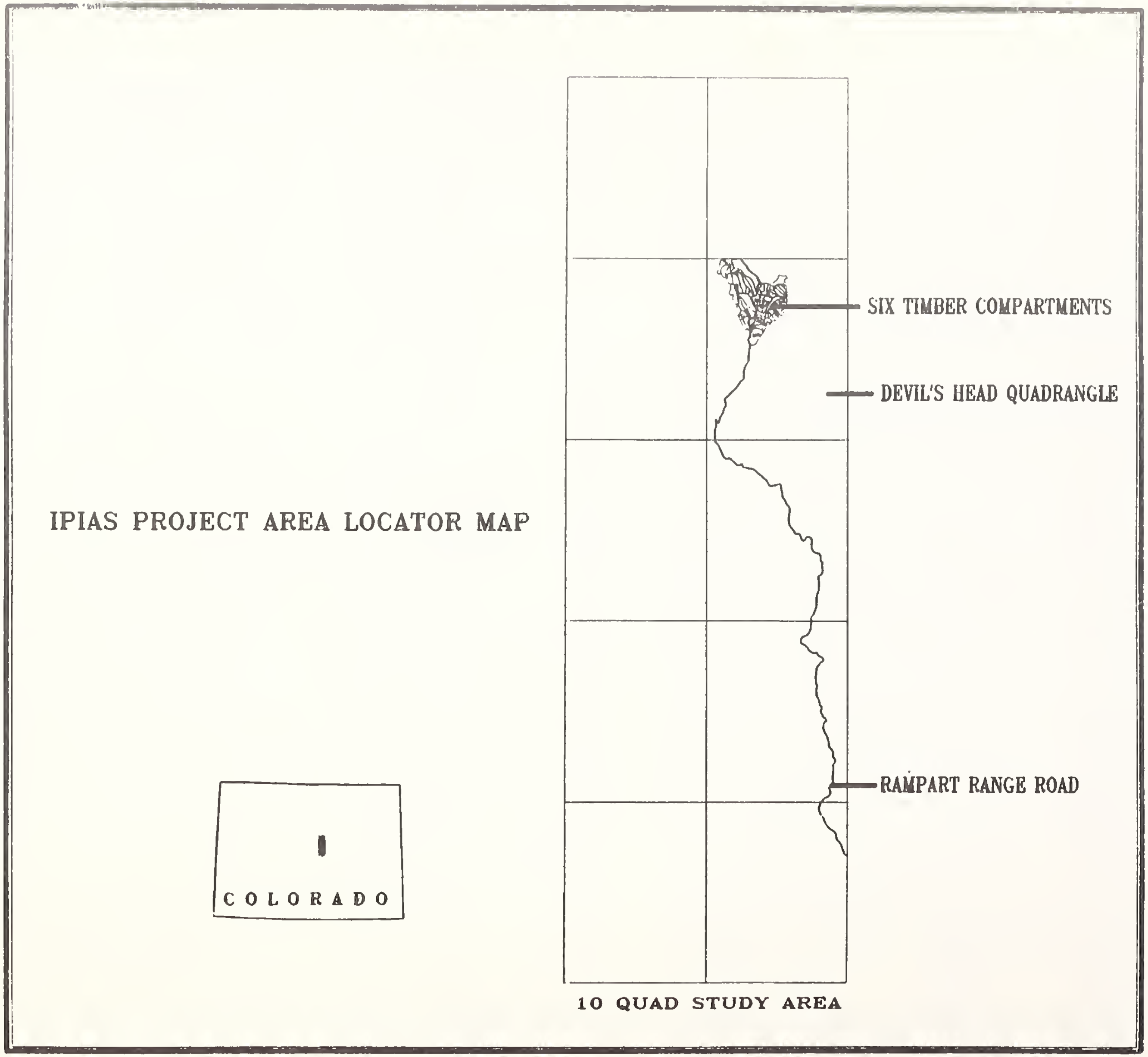

Figure 3 - Project area locator map (computer output).

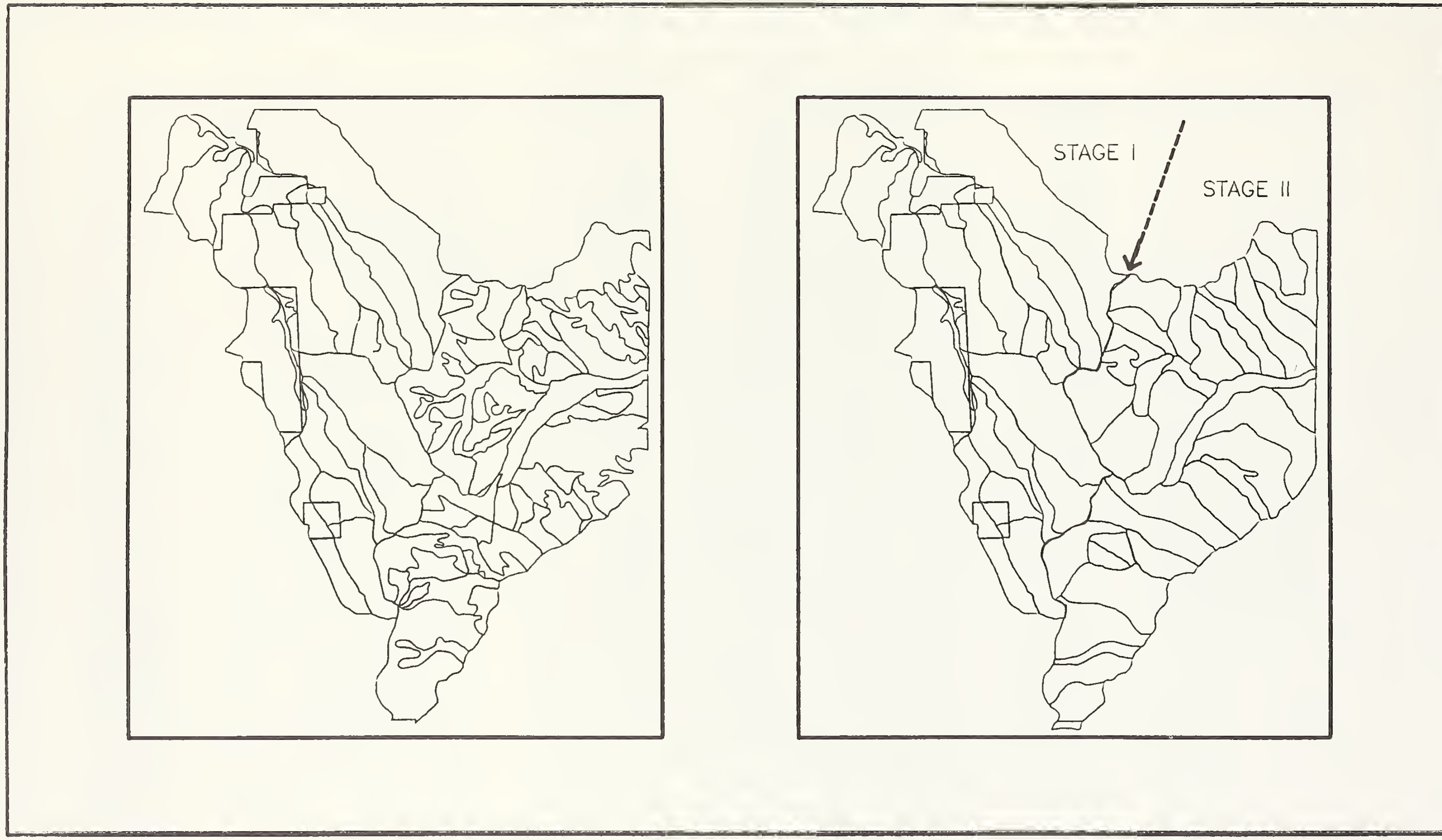

Figure 4 - Six-compartment project area displaying Stage I (left) and Stage II (right) stand boundaries (computer output). Stands outside this six-compartment area would be the same for both examples and for illustration purposes have not been displayed.

OPERATION AND OUTPUT - After the Stage II data have been incorporated into IPIAS, the following operations are executed using the most recent (Stage I or Stage II) data available for each stand:

(1) *Select all ponderosa pine stands of sawtimber size.*

(2) *Of the above set of stands, select the ones with MPB-caused mortality exceeding 0.1 trees/acre.*

(3) *Of the above set of stands, select all stands with slopes <40%.*

(4) *Buffer the Rampart Range Road 0.5 mile on either side, and display the buffer area and the stands that meet criteria 1-3 (fig. 5, left).*

(5) *Display the "seen area", based on direct field survey, from Devil's Head vista within the six-compartment study area and overlay with the stands that satisfy criteria 1-3 (fig. 5, right).*

Up to four management alternatives for the selected stands can now be formulated based on analyses of these and other data, management directives, and constraints relevant to the area. The selected alternatives are input to the STAND model (GROW) which, in interaction with the PEST model (MPB), can project residual (after growth, normal mortality, MPB-caused mortality, and harvest treatments) stand characteristics for up to six time periods (3, 8, 18, 28, 38, and 48 years in this example) for each management alternative. The residual stand characteristics are input to the socioeconomic model and economic, recreation, property, and perceived scenic value estimates computed and added to the tabular data base for each stand.

A tabular comparison of two or more treatment alternatives for certain stands or for sets of stands meeting specified criteria (e.g., all stands within the 0.5 mile buffer, and within the "seen area" of the vista point, or both, can be requested from IPIAS). Comparisons can be made for any selected subsets of the tabular data base, including residual stand characteristics, insect damage, and socioeconomic impact projections for any of the time periods modeled.

For example, tables 1a and 1b show a comparison of No Treatment and Basal Area Reduction (top down) alternatives for year 3. In terms of predicted MPB-caused mortality, residual basal area (≥5 inches DBH), residual saw timber volume, cut timber revenues (based on user-specified stump price and discount rate), loss of timber revenues (sawtimber that was killed by MPB at least 3 years earlier), recreation potential (aggregated over user-designated activities), and perceived on-site scenic value (expressed as a percentile rank based on values for a large sample of ponderosa pine sites along the Front Range). The same comparison of alternatives is shown in tables 2a and 2b for year 18.

The variables shown in tables 1a, 1b, 2a, and 2b are representative of the large number of forest, insect, and socioeconomic variables that can be displayed with IPIAS. These tables, along with graphs, such as the one in

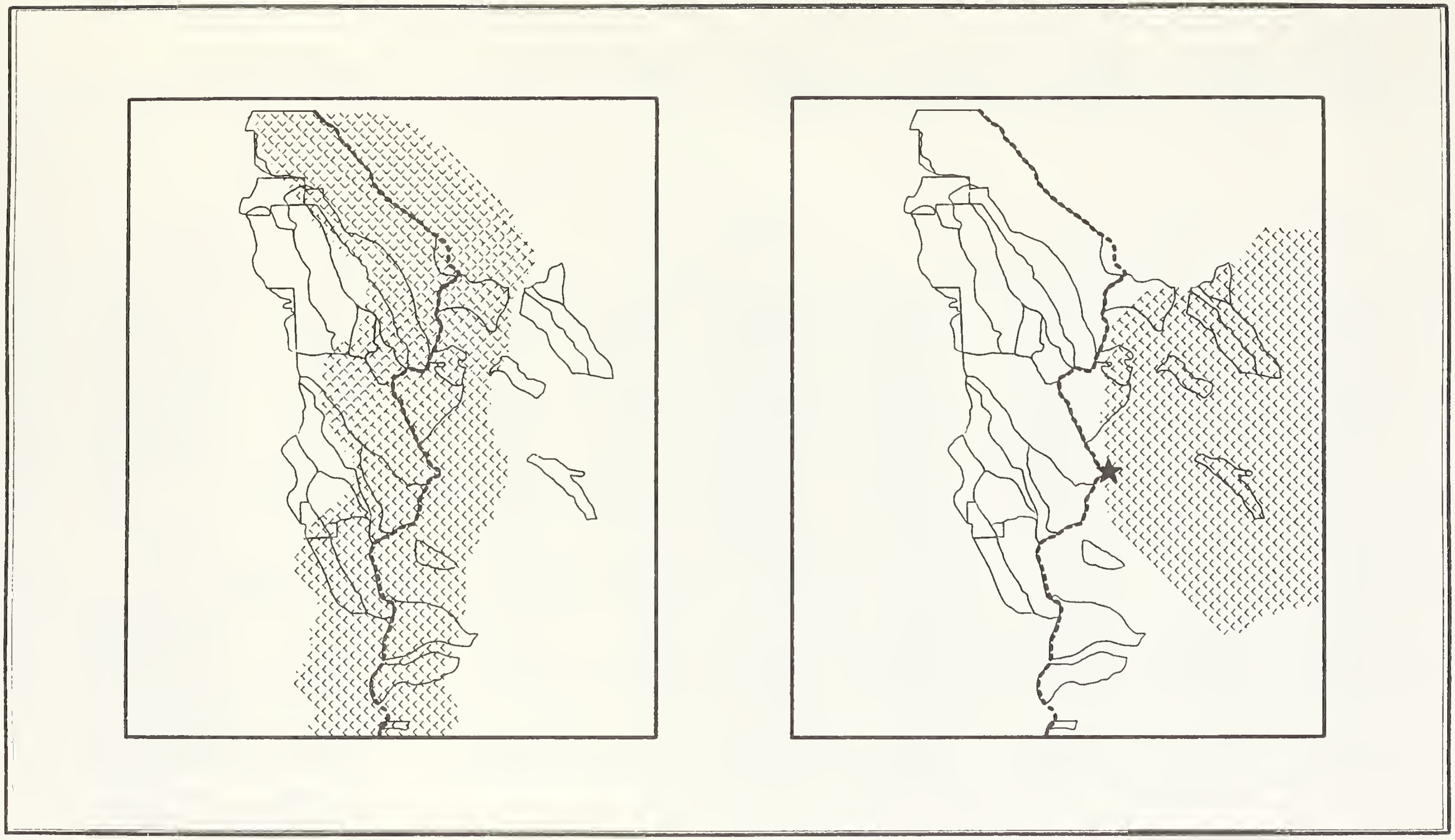

Figure 5 - Ponderosa pine stands of saw timber size with MPB-caused mortality 0.1 tree/acre on slopes less than 40% within a 0.5 mile buffer along the Rampart Range Road (left) and the "seen area" from Devils Head Vista Point (*) (right) (computer output).

STAND ID #	# OF ACRES	MPB HITS	RESID. AREA (5+)	RESID. TIMBER (BD FT)	CUT TIMBER ($)	LOSS TIMBER ($)	REC. POTNTL. (DAYS)	SBE % ON SITE
INVENTORY DATE = 1/79, STAGE 1 :								
2270102	386							
2270104	039							
2270105	024							
2270106	033	1.200	081	2900	0000	0000	07.1	54.4
2270204	205							
2270401	055							
2270403	048							
2270405	080	0.700	089	3200	0000	0000	07.1	54.4
2270406	087							
INVENTORY DATE = 1/79, STAGE 2 :								
2290104	048	0.754	122	4729	0000	0000	18.4	58.3
2290106	053	0.955	070	1698	0000	0000	15.9	18.7
2290107	057	1.029	074	1476	0000	0000	17.4	45.6
2290108	063	1.029	109	3682	0000	0000	18.4	43.6
2290117	091	0.739	084	3549	0000	0000	16.6	37.8
2290212	040	0.450	063	1467	0000	0000	16.6	52.4
2290213	093	0.323	081	2569	0000	0000	17.5	42.9
2290215	062	0.449	079	2106	0000	0000	17.9	30.8
2290216	026	0.039	073	1975	0000	0000	14.7	43.6
MEAN VALUES:								
	72.8	.761	73.3	2442.0	0	0	10.6	42.2

Table 1a - No Treatment, values for year 3, Pike/San Isabel National Forest, Colorado. All data given in (units)/ per acre. (Tables 1a, 1b, 2a, and 2b are computer output. Projections for Stage I stands are aggregated by homogeneous analysis areas. See text for an explanation of the table headings.)

STAND ID #	# OF ACRES	MPB HITS	RESID. AREA (5+)	RESID. TIMBER (BD FT)	CUT TIMBER ($)	LOSS TIMBER ($)	REC. POTNTL. (DAYS)	SBE % ON SITE
INVENTORY DATE = 1/79, STAGE 1 :								
2270102	386							
2270104	039							
2270105	024							
2270106	033	1.200	033	0700	37.6	0000	07.1	47.6
2270204	205							
2270401	055							
2270403	048							
2270405	080	0.700	036	0800	42.4	0000	07.1	46.8
2270406	087							
INVENTORY DATE = 1/79, STAGE 2 :								
2290104	048	0.754	068	2077	46.4	0000	17.2	51.6
2290106	053	0.955	041	0421	22.3	0000	14.9	18.7
2290107	057	1.029	031	0443	18.1	0000	14.9	34.1
2290108	063	1.029	044	1476	38.6	0000	17.5	44.0
2290117	091	0.739	036	1348	38.5	0000	14.2	32.6
2290212	040	0.450	027	0552	16.0	0000	12.2	54.0
2290213	093	0.323	033	0922	28.8	0000	14.3	41.3
2290215	062	0.449	037	0922	20.7	0000	15.8	31.2
2290216	026	0.039	029	0509	25.7	0000	11.4	37.8
MEAN VALUES:								
	72.8	.761	31.7	741.6	29.4	0	9.5	37.7

Table 1b - Basal Area Reduction in year 3, values for year 3, Pike/San Isabel National Forest, Colorado. All data given in (units)/ per acre.

STAND ID #	# OF ACRES	MFB HITS	RESID. AREA (5+)	RESID. TIMBER (BD FT)	CUT TIMBER ($)	LOSS TIMBER ($)	REC. POTNTL. (DAYS)	SBE % ON SITE
INVENTORY DATE = 1/79, STAGE 1 :								
2270102	386							
2270104	039							
2270105	024							
2270106	033	*****	066	2900	0000	25.5	07.1	55.6
2270204	205							
2270401	055							
2270403	048							
2270405	080	*****	089	4100	0000	17.8	07.1	56.8
2270406	087							
INVENTORY DATE = 1/79, STAGE 2 :								
2290104	048	*****	092	6762	0000	37.7	14.0	58.3
2290106	053	*****	088	5406	0000	17.8	16.5	20.6
2290107	057	*****	067	2020	0000	09.3	15.9	47.2
2290108	063	*****	115	5922	0000	12.7	18.8	49.2
2290117	091	*****	056	4180	0000	30.6	11.5	46.8
2290212	040	*****	085	3932	0000	03.3	15.6	67.7
2290213	093	*****	084	4347	0000	10.6	15.5	51.2
2290215	062	*****	077	3693	0000	12.0	15.7	45.6
2290216	026	*****	091	4256	0000	00.7	13.9	39.7
MEAN VALUES:								
	72.8	0	68.2	3374.2	0	18.0	9.8	45.4

Table 2a - No Treatment - values for year 18, Pike/San Isabel National Forest, Colorado.
All data given in (units)/per acre.

STAND ID #	# OF ACRES	MPB HITS	RESID. AREA (5+)	RESID. TIMBER (BD FT)	CUT TIMBER ($)	LOSS TIMBER ($)	REC. POTNTL. (DAYS)	SBE % ON SITE
INVENTORY DATE = 1/79, STAGE 1 :								
2270102	386							
2270104	039							
2270105	024							
2270106	033	*****	052	2100	39.8	00.1	07.1	50.0
2270204	205							
2270401	055							
2270403	048							
2270405	080	*****	049	2400	44.6	00.2	07.1	51.2
2270406	087							
INVENTORY DATE = 1/79, STAGE 2 :								
2290104	048	*****	075	5440	59.2	16.8	12.9	54.8
2290106	053	*****	027	1950	42.2	00.3	09.8	28.1
2290107	057	*****	005	0234	21.9	00.1	07.3	55.2
2290108	063	*****	043	3423	39.5	0000	11.7	52.4
2290117	091	*****	042	2942	47.3	00.1	10.7	34.5
2290212	040	*****	050	2656	16.1	0000	12.1	59.5
2290213	093	*****	054	2688	28.9	0000	13.3	59.1
2290215	062	*****	070	3186	21.8	0000	15.2	38.6
2290216	026	*****	019	1310	28.8	0000	08.3	39.7
MEAN VALUES:								
	72.8	0	41.4	2118.3	32.9	.8	8.0	42.7

Table 2b - Basal Area Reduction - in year 3, values for year 18, Pike/San Isabel National Forest, Colorado. All data given in (units)/per acre.

figure 6, provide information to the forest manager about the implications of the alternative treatments under consideration. IPIAS does not combine effects into weighted sums or otherwise compute an "optimum" value or select the "best" alternative; that is appropriately left up to the decisionmaker. IPIAS does make information on the costs, benefits, and trade-offs among management alternatives available to the decisionmaker by displaying the magnitude, timing, and spatial distribution of a variety of forest and socioeconomic effects.

SUMMARY

Although IPIAS is not an "on-the-shelf" system ready for wide application in forest management, many of its components are in extensive use by forest managers in the U.S. Forest Service and by personnel in other land management agencies as well. MOSS, S2K, and the GROW model are widely used. Many of the economic model components are based on accepted price and discount functions and, therefore, have wide application. Some components, such as the scenic value models, have been extensively tested in the Front Range area, but may not be applicable beyond that set of forest conditions. The MPB model component requires additional testing and development, as do most of the socioeconomic models. The general framework, however, works very well and potentially can be of tremendous benefit to forest managers and planners.

Implementation of an IPIAS-type system within current forest management and planning procedures could take a form similar to that in figure 7. The starting point is always an inventory of relevant forest resources. The inventory must be complete enough to operate the STAND model. In a typical IPIAS application, the timber staff and forest silviculturalist would run the STAND model, providing the needed parameters and formulating appropriate harvest, thinning, and pest management activities. Pest management specialists would provide up-to-date infestation or damage inventories and other parameters (e.g., attack ratios for insects) needed to integrate the PEST model with the STAND model. Output from the STAND model would drive a set of resource models, each operated and interpreted by the appropriate planning or management specialist. For each modeled management alternative, resource specialists would provide their evaluation and recommendations, supported by the related model projections of location, timing, and magnitude of predicted effects.

IPIAS was designed to augment existing forest planning and management procedures and to incorporate the interdisciplinary team approach used in forest planning. The principal modifications of that process are the close link between the data base management and geographic information systems and the use of interrelated quantitative models. Mathematical stand growth and economic models are already routinely used and of great value to timber specialists and economists. Recreation, wildlife, and scenic value models are not generally available at this time. When developed and integrated into a comprehensive information system, such models can enhance the precision, reliability, and usefulness of socioeconomic variables in the forest planning and decisionmaking process. For now, projecting impacts of forest change on

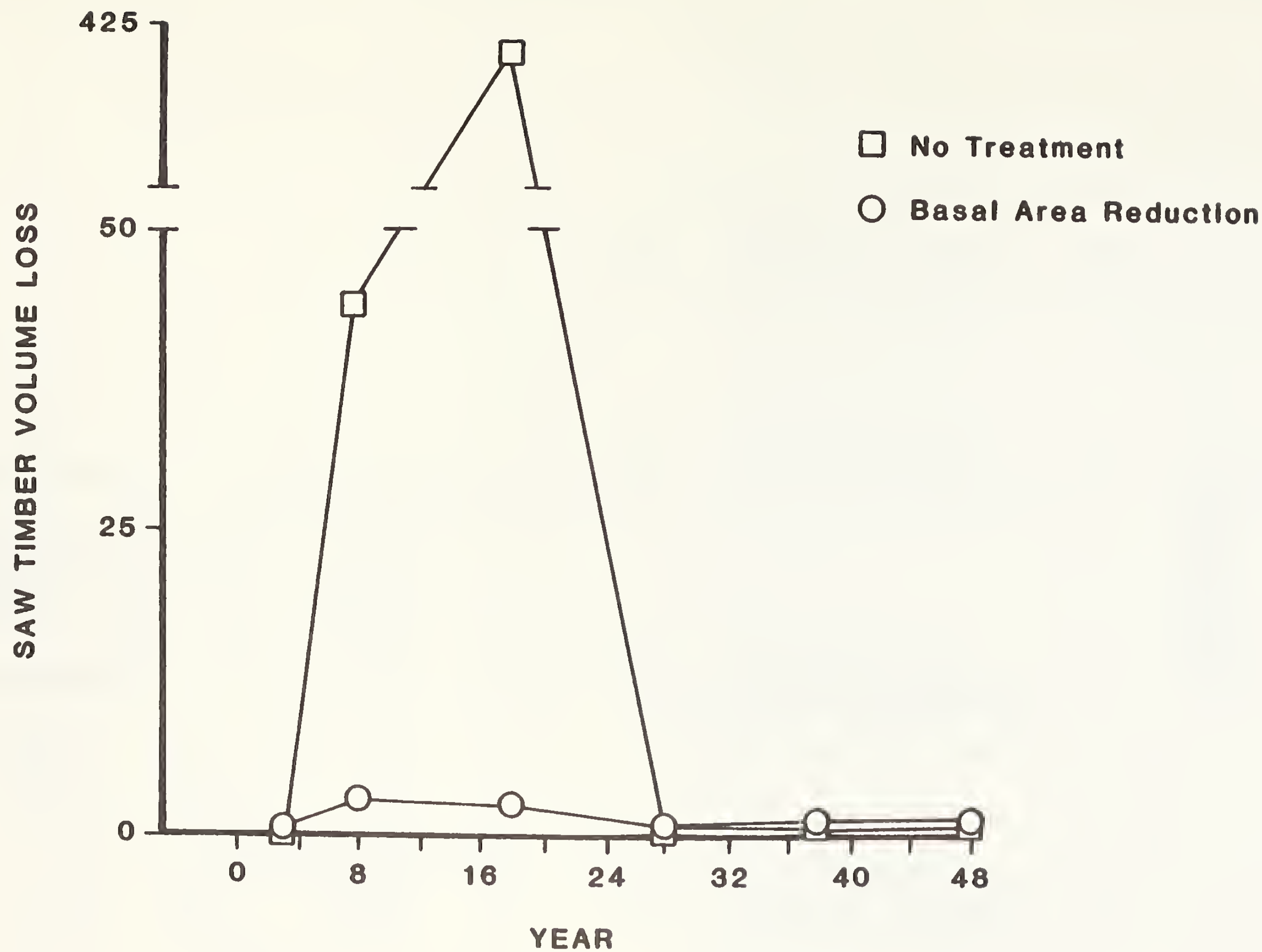

Figure 6 - Projected saw timber loss (cubic feet per acre) due to mountain pine beetle under No Treatment and Basal Area Reduction management alternatives.

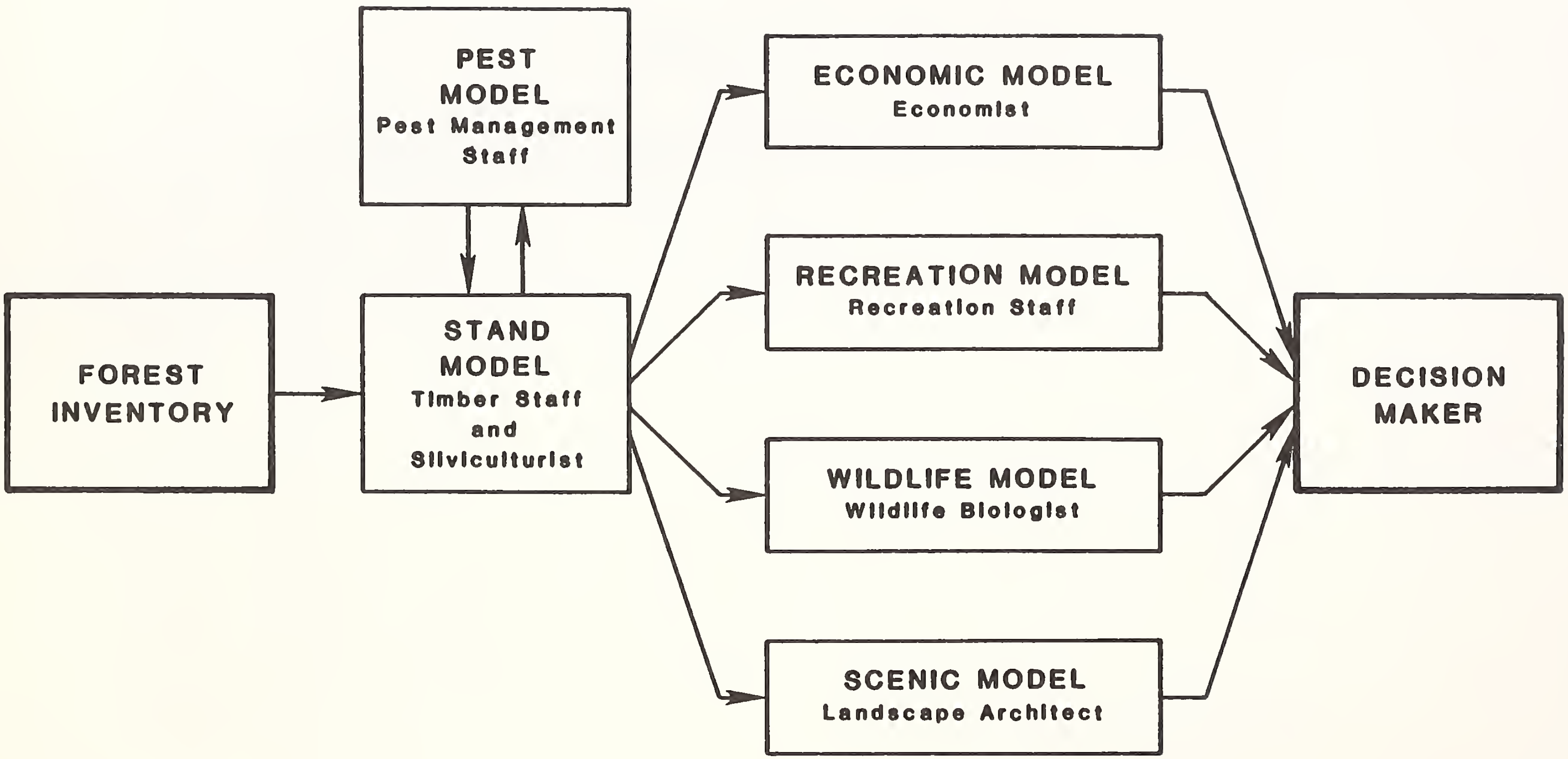

Figure 7 - Schematic outline of IPIAS as implemented within a general forest planning framework.

this type of variable must be based largely on the implicit, informal models used by individual resource specialists.

There are several different areas of forest planning where IPIAS could be a very useful tool for the forest manager. For example, the DBMS and GIS components can be used to facilitate compiling, analyzing, updating, and accessing basic inventory information at all stages of forest planning. IPIAS can be used in the identification and mapping of homogeneous analysis areas and in the formulation and selection of a set of candidate management strategies to be subjected to a FORPLAN decision model. The socioeconomic components of IPIAS can be used to facilitate setting appropriate constraints for FORPLAN and to provide a basis for directly including recreation and scenic considerations in the decisionmaking process. After general management goals and guidelines are determined through the FORPLAN process, IPIAS can be used to assign treatments to specific stands (project planning) and to moniter progress toward management goals. Because IPIAS is a "user friendly" interactive computer system, there is close interaction among all components of the planning process, increasing the value of the system for forest managers.

Forest Pest Management personnel of the U.S. Forest Service sponsored a workshop in March, 1983, to review and evaluate the MPB version of IPIAS and to develop a 5-year plan for future work. Over 40 forest planners, managers, resource specialists, and scientists from throughout the Nation participated in the workshop. While there was considerable discussion of the strengths and weaknesses of specific model components, there was concensus that the general IPIAS framework was valid and worthy of future effort. A 5-year research and development proposal has been drafted by Forest Pest Management personnel and is currently under consideration by Forest Service administration (Anonymous 1983b).

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